JAPAN

EDICT OF GOVERNMENT

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JIS B 9960-11 (2004) (English): Safety of machinery -- Electrical equipment of machines -- Part 11: Requirements for HV equipment for voltages above 1000V a.c. or 1500V d.c. and not exceeding 36kV

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The citizens of a nation must honor the laws of the land.

Fukuzawa Yukichi

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JIS

JAPANESE
INDUSTRIAL
STANDARD

Translated and Published by
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JIS B 9960-11 : 2004

(JMF)

Safety of machinery—Electrical equipment of machines—Part 11 : Requirements for HV equipment for voltages above 1 000 V a.c. or 1 500 V d.c. and not exceeding 36 kV

ICS 13.110; 29.020

Reference number : JIS B 9960-11 : 2004 (E)

Foreword

This translation has been made based on the original Japanese Industrial Standard established by the Minister of Health, Labour and Welfare, and the Minister of Economy, Trade and Industry through deliberations at the Japanese Industrial Standards Committee according to the proposal of establishing a Japanese Industrial Standard from the Japan Machinery Federation (JMF), with a draft of Industrial Standard based on the provision of Article 12 Clause 1 of the Industrial Standardization Law.

This Standard has been made based on **IEC 60204-11** : 2000 *Safety of machinery—Electrical equipment of machines—Part 11 : Requirements for HV equipment for voltages above 1 000 V a.c. or 1 500 V d.c. and not exceeding 36 kV* for the purposes of making it easier to compare this Standard with International Standard; to prepare Japanese Industrial Standard conforming with International Standard; and to propose a draft of an International Standard which is based on Japanese Industrial Standard.

Attention is drawn to the possibility that some parts of this Standard may conflict with a patent right, application for a patent after opening to the public, utility model right or application for registration of utility model after opening to the public which have technical properties. The relevant Minister and the Japanese Industrial Standards Committee are not responsible for identifying the patent right, application for a patent after opening to the public, utility model right or application for registration of utility model after opening to the public which have the said technical properties.

JIS B 9960 consists of the following 4 parts under the general title *Safety of machinery—Electrical equipment of machines.*

Part 1 : General requirements

Part 11 : Requirements for HV equipment for voltages above 1 000 V a.c. or 1 500 V d.c. and not exceeding 36 kV

Part 31 : Particular safety and EMC requirements for sewing machines, units and systems

Part 32 : Requirements for hoisting machines.

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In the event of any doubts arising as to the contents, the original JIS is to be the final authority.

Contents

Safety of machinery— Electrical equipment of machines— Part 11 : Requirements for HV equipment for voltages above 1 000 V a.c. or 1 500 V d.c. and not exceeding 360 kV

Introduction This Japanese Industrial Standard has been prepared based on the first edition of **IEC 60204-11** *Safety of machinery—Electrical equipment of machines—Part 11 : Requirements for HV equipment for voltages above 1 000 V a.c. or 1 500 V d.c. and not exceeding 36 kV* published in 2000 with some modifications of the technical contents.

Portions given sidelines or dotted underlines are the matters modified from the original International Standard. A list of modifications with the explanations is given in annex 1 (informative).

This Standard provides requirements and recommendations relating to the high voltage electrical equipment (HV equipment) of machines together with its associated low voltage electrical equipment (LV equipment) so as to promote

— safety of persons and property;

— consistency of control response;

— ease of maintenance.

High performance is not to be obtained at the expense of the essential factors mentioned above.

An example of a possible application of these requirements is a machine or group of machines used for the processing of a material where a failure in such machinery can have serious economic consequences.

Figure 1 is a block diagram of a machine and associated equipment showing the various elements of the electrical equipment addressed in this Standard. Numbers in parentheses refer to clauses and subclauses in this Standard. It is understood that all of the elements taken together including the safeguards, software and the documentation constitute the machine or group of machines working together with usually at least one level of supervisory control.

More guidance on the use of this Standard is given in annex F (informative) of **JIS B 9960-1**.

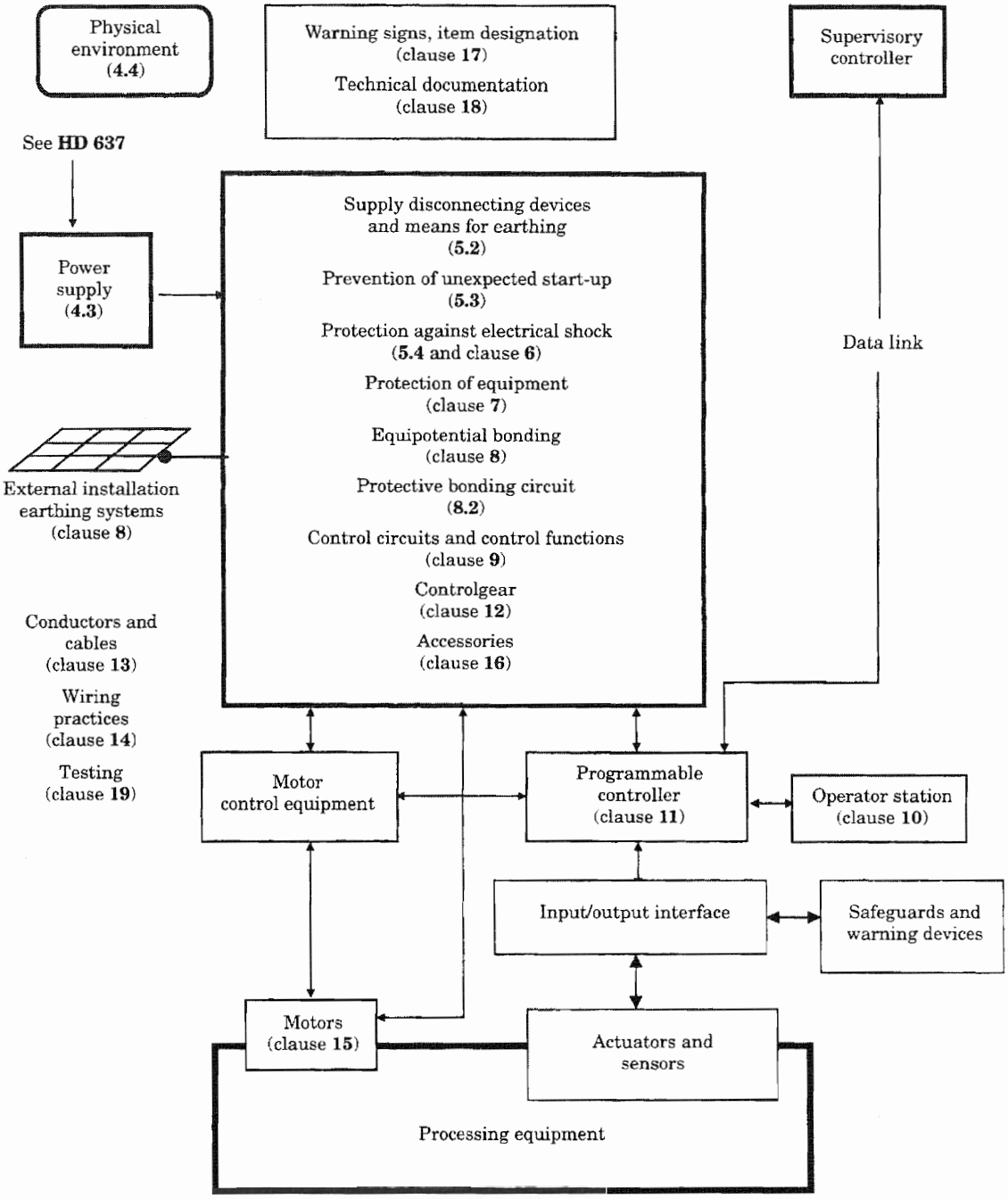


Figure 1 Block diagram of a machine containing HV equipment

1 Scope **JIS B 9960** applies to the electrical and electronic equipment and systems of machines, including a group of machines working together in a coordinated manner, but excluding higher level system aspects (i.e. communications between systems).

This part of **JIS B 9960** is applicable to equipment, or parts of equipment, which operate with nominal supply voltages above 1 000 V a.c. or 1 500 V d.c. and not exceeding 36 kV a.c. or d.c. with nominal frequencies not exceeding 200 Hz. For higher voltages or frequencies, special requirements may be needed.

In this Standard, the term HV equipment also covers the LV equipment forming an integral part of the equipment operating at high voltage. The requirements in this Standard primarily cover the parts operating at high voltage except where explicitly stated otherwise. Reference is made to **JIS B 9960-1** for those requirements which also apply to HV equipment.

NOTES 1 Other LV equipment not forming part of the HV equipment and defined as operating at voltages not exceeding 1 000 V a.c. or 1 500 V d.c. are covered by **JIS B 9960-1**.

2 In this Standard, the term "electrical" includes both electrical and electronic matters i.e. electrical equipment means both the electrical and the electronic equipment.

The electrical equipment covered by this part of **JIS B 9960** commences at the point of connection of the supply to the electrical equipment of the machine (see **5.1**).

Information : For power supply installations, CENELEC documents define the requirements (**HD 637** Power supply installations exceeding 1 000 V a.c.). **HD** refers to the Harmonized Document of CENELEC.

This part of **JIS B 9960** is an application standard and is not intended to limit or inhibit technological advancement. It does not cover all the requirements (e.g. guarding, interlocking or control) which are needed or required by other standards or regulations in order to safeguard personnel from hazards other than electrical hazards. Each type of machine has unique requirements to be accommodated to provide adequate safety.

NOTE 3 In the context of this Standard, the term "person" refers to any individual; "personnel" are those persons who are assigned and instructed by the user or his agent(s) in the use and care of the machine in question.

This part of **JIS B 9960** specifically includes, but is not limited to, machines as defined in **3.26**, annex A lists examples of machines whose electrical equipment may be covered by this Standard.

Additional and special requirements can apply to the electrical equipment of machines that

— are used in the open air (i.e. outside buildings or other protective structures);

— use, process or produce potentially explosive material (e.g. paint or sawdust);

— are used in potentially explosive and/or flammable atmospheres;

— have special risks when producing or using certain materials;

— are used in mines.

Power circuits where electrical energy is directly used as a working tool are excluded from this Standard.

NOTE 4 The International Standard corresponding to this Standard is as follows.

In addition, symbols which denote the degree of correspondence in the contents between the relevant International Standard and **JIS** are IDT (identical), MOD (modified), and NEQ (not equivalent) according to **ISO/IEC Guide 21**.

IEC 60204-11 : 2000 *Safety of machinery—Electrical equipment of machines—Part 11 : Requirements for HV equipment for voltages above 1 000 V a.c. or 1 500 V d.c. and not exceeding 36 kV* (MOD)

2 Normative references The following standards contain provisions which, through reference in this Standard, constitute provisions of this Standard. If the indication of the year of coming into effect or the year of publication is given to these referred standards, only the edition of the indicated year constitutes the provision of this Standard but the revision and amendment made thereafter do not apply.

JIS B 9706-1 : 2001 *Safety of machinery—Indication, marking and actuation—Part 1 : Requirements for visual, auditory and tactile signals*

NOTE : **IEC 61310-1** : 1995 *Safety of machinery—Indication, marking and actuation—Part 1 : Requirements for visual, auditory and tactile signals* is identical with the said standard.

JIS B 9706-3 : 2001 *Safety of machinery—Indication, marking and actuation—Part 3 : Requirements for the location and operation of actuators*

NOTE : **IEC 61310-3** : 1999 *Safety of machinery—Indication, marking and actuation—Part 3 : Requirements for the location and operation of actuators* is identical with the said standard.

JIS B 9960-1 : 1999 *Safety of machinery—Electrical equipment of machines—Part 1 : General requirements*

NOTE : **IEC 60204-1** : 1997 *Safety of machinery—Electrical equipment of machines—Part 1 : General requirements* is equivalent to the said standard.

JIS C 0364-4-41 : 1997 *Electrical installations of buildings Part 4 : Protection for safety Chapter 41 : Protection against electric shock*

NOTE : **IEC 60364-4-41** : 1992 *Electrical installations of buildings—Part 4 : Protection for safety—Chapter 41 : Protection against electric shock* is identical with the said standard.

JIS C 0364-4-42 : 1999 *Electrical installations of buildings Part 4 : Protection for safety Chapter 42 : Protection against thermal effects*

NOTE : **IEC 60364-4-42** : 1980 *Electrical installations of buildings—Part 4 : Protection for safety—Chapter 42 : Protection against thermal effects* is identical with the said standard.

JIS C 0364-5-54 : 1997 *Electrical installations of buildings Part 5 : Selection and erection of electrical equipment Chapter 54 : Earthing arrangements and protective conductors*

NOTE : **IEC 60364-5-54** : 1980 *Electrical installations of buildings—Part 5 : Selection and erection of electrical equipment—Chapter 54 : Earthing arrangements and protective conductors* is identical with the said standard.

JIS C 0445 : 1999 *Identification of equipment terminals and of terminations of certain designated conductors, including general rules for an alphanumeric system*

NOTE : **IEC 60445** : 1999 *Basic and safety principles for man-machine interface, marking and identification—Identification of equipment terminals and of terminations of certain designated conductors, including general rules for an alphanumeric system* is identical with the said standard.

JIS C 0920 : 1993 *Tests to prove protection against ingress of water and degrees of protection against ingress of solid objects for electrical equipment*

NOTE : **IEC 60529** : 1989 *Degrees of protection provided by enclosures (IP Code)* is equivalent to the said standard.

JIS C 4606 : 1993 *6.6 kV disconnectors for indoor use*

NOTE : **IEC 60129** : 1984 *Alternating current disconnectors and earthing switches* is equivalent to the said standard.

JIS Z 9101 : 1995 *Safety colours and safety signs*

NOTE : **ISO 3864** : 1984 *Safety colours and safety signs* is equivalent to the said standard.

IEC 60050 (191) : 1990 *International Electrotechnical Vocabulary (IEV)—Chapter 191: Dependability and quality of service*

IEC 60050 (195) : 1998 *International Electrotechnical Vocabulary (IEV)—Part 195: Earthing and protection against electric shock*

IEC 60050 (441) : 1984 *International Electrotechnical Vocabulary (IEV)—Chapter 441: Switchgear, controlgear and fuses*

IEC 60050 (826) : 1982 *International Electrotechnical Vocabulary (IEV)—Chapter 826: Electrical installations of buildings*

IEC 60050 (826) : 1995 *Amendment No. 2*

IEC 60071-1: 1993 *Insulation co-ordination—Part 1 : Definitions, principles and rules*

IEC 60071-2 : 1996 *Insulation co-ordination—Part 2 : Application guide*

IEC 60076-5 : 1976 *Power transformers—Part 5 : Ability to withstand short-circuit*

IEC 60298 : 1990 *A.C. metal-enclosed switchgear and controlgear for rated voltages above 1 kV and up to and including 52 kV*

IEC 60417 (all parts) : 1973 *Graphical symbols for use on equipment*

IEC 60466 : 1987 *A.C. insulation-enclosed switchgear and controlgear for rated voltages above 1 kV and up to and including 38 kV*

IEC 60621-3 : 1979 *Electrical installations for outdoor sites under heavy conditions (including open-cast mines and quarries)—Part 3 : General requirements for equipment and ancillaries*

IEC 60694 : 1996 *Common specifications for high-voltage switchgear and controlgear standards*

IEC 60865-1 : 1993 *Short-circuit currents—Calculation of effects—Part 1 : Definitions and calculation methods*

IEC 61230 : 1993 *Live working—Portable equipment for earthing or earthing and short-circuiting*

IEC 61243-1 : 1993 *Live working—Voltage detectors—Part 1 : Capacitive type to be used for voltages exceeding 1 kV a.c.*

ISO 12100-1 : 2003 *Safety of machinery—Basic concepts, general principles for design—Part 1 : Basic terminology, methodology*

3 Definitions For the purpose of this Standard, the following principal definitions apply.

3.1 ambient temperature temperature of the air or other medium where the equipment is to be used [see **IEC 60050-(826), 01-04**]

3.2 barrier part providing protection against direct contact from any usual direction of access [see **IEC 60050-(826), 03-13**]

3.3 cable tray cable support consisting of a continuous base and raised edges and no covering [see **IEC 60050-(826), 06-07**]

NOTE : A cable tray may be perforated or non-perforated.

3.4 control circuit (of a machine) circuit used for the operational control of the machine and for protection of the power circuits

3.5 control device device connected into the control circuit and used for controlling the operation of the machine (e.g. position sensor, manual control switch, relay, magnetically operated valve)

3.6 controlgear general term covering switching devices and their combination with associated control, measuring, protective, and regulating equipment, also assemblies of such devices and equipment with associated interconnections, accessories, enclosures, and supporting structures [see **IEC 60050-(441)**]

3.7 direct contact electric contact of persons or animals with live parts [see **IEC 60050-(195), 06-03**]

3.8 duct enclosed channel designed expressly for holding and protecting electrical conductors, cables, and busbars

NOTE : Conduits, cable trunking systems and underfloor channels are types of duct.

3.9 earthing system locally limited system of conductively connected earth electrodes or metal parts of equal effectiveness (for example tower footings, armourings, metal cable sheaths), of earthing conductors and of bonding conductors (see figure 2)

Information : **HD 637**, **2.7.6** also defines identically.

3.10 electrical operating area room or location for electrical equipment to which access is intended to be restricted to skilled or instructed persons, by the opening of a door or the removal of a barrier without the use of a key or tool, and which is clearly marked by appropriate warning signs.

NOTE : (**electrically**) **instructed person**: A person adequately advised or supervised by an electrically skilled person to enable him or her to perceive risks and to avoid hazards which electricity can create [**IEC 60050-(826)**, **09-02**, modified]

(**electrically**) **skilled person**: A person with relevant education and experience to enable him or her to perceive risks and to avoid hazards which electricity can create [**IEC 60050-(826)**, **09-02**, modified], (see also **JIS B 9960-1**, **3.28** and **3.52**)

3.11 electronic equipment part of the electrical equipment containing circuitry mainly based on electronic devices and components

3.12 enclosed electrical operating area room or location for electrical equipment to which access is intended to be restricted to skilled or instructed persons by the opening of a door or the removal of a barrier by the use of a key or tool and which is clearly marked by appropriate warning signs

NOTE : See also NOTE to definition **3.10**.

3.13 enclosure part providing protection of equipment against certain external influences and, in any direction, protection against direct contact (**IEV 826-03-12**)

NOTE : The definition taken from the existing **IEV** needs the following explanations under the scope of this Standard (see **JIS C 0920**, **3.1**):

a) enclosures provide protection of persons or livestock against access to hazardous parts;

b) barriers, shaped openings, or any other means suitable to prevent or limit the penetration of the specified test probes, whether attached to the enclosure or formed by the enclosed equipment, are considered as part of the enclosure, except where they can be removed without the use of a key or tool.

An enclosure may be

— a cabinet or box, either mounted on the machine or separate from the machine;

— a compartment consisting of an enclosed space within the machine structure.

3.14 equipment general term including material, fittings, devices, appliances, fixtures, apparatus, and the like used as part of, or in connection with, an electrical installation.

3.15 equipotential bonding provision of electric connections between conductive parts, intended to achieve equipotentiality [see **IEC 60050-(195), 01-10**]

3.16 equipotential bonding conductor/protective bonding conductor protective conductor provided for protective-equipotential-bonding [see **IEC 60050-(195), 02-10**]

3.17 exposed-conductive-part conductive part of equipment which can be touched and which is not normally live, but which can become live when basic insulation fails [see **IEC 60050-(195), 06-10**]

3.18 extraneous-conductive-part conductive part not forming part of the electrical installation and liable to introduce an electric potential, generally the electric potential of a local earth [see **IEC 60050-(195), 06-11**]

3.19 failure termination of the ability of an item to perform a required function

NOTES 1 After failure the item has a fault.

2 "Failure" is an event, as distinguished from "fault", which is a state.

3 This concept as defined does not apply to items consisting of software only [see **IEC 60050-(191), 04-01**].

4 In practice the terms fault and failure are often used synonymously.

3.20 fault state of an item characterized by inability to perform a required function, excluding the inability during preventive maintenance or other planned actions, or due to lack of external resources

NOTE : A fault is often the result of a failure of the item itself, but may exist without prior failure.

3.21 hazard source of possible injury or damage to health (see **ISO 12100-1, 3.5**)

3.22 indirect contact electric contact of persons or animals with exposed-conductive-parts which have become live under fault conditions [see **IEC 60050-(195), 06-04**]

3.23 interlock (for safeguarding) arrangement that interconnects guard(s) or device(s) with the control system and/or all or part of the electrical energy distributed to the machine

3.24 live part conductor or conductive part intended to be energized in normal operation, including a neutral conductor, but by convention not a PEN conductor or PEM conductor (protective earthing mid-point conductor) or PEL conductor (protective earthing line conductor) [see **IEC 60050-(195), 06-04**]

NOTE : This concept does not necessarily imply a risk of electric shock.

3.25 machine bonding conductor conductor connecting the machine equipotential bonding to the earthing system [see **IEC 60050-(826), 04-07**]

Information : This is an earthing conductor as defined and used in **HD 637**.

3.26 machinery (machine) An assembly of linked parts or components, at least one of which moves, with the appropriate machine actuators, control and power circuits, etc., joined together for a specific application, in particular for the processing, treatment, moving or packaging of a material.

The term "machinery" also covers an assembly of machines which, in order to achieve one and the same end, are arranged and controlled so that they function as an integral whole.

"Machinery" also means interchangeable equipment modifying the function of a machine, which is placed on the market (supplied) for the purpose of being assembled with a machine or a series of different machines, or with a tractor by the operator himself insofar as this equipment is not a spare part or tool.

3.27 marking signs or inscriptions for the identification of the type of a component or device attached by the manufacturer of the component or device

3.28 neutral conductor conductor electrically connected to the neutral point and capable of contributing to the distribution of electric energy [see **IEC 60050-(195), 02-06**]

3.29 obstacle part preventing unintentional direct contact, but not preventing direct contact by deliberate action [see **IEC 60050-(826), 03-14**]

3.30 overcurrent current exceeding the rated value. For conductors, the rated value is the current-carrying capacity [see **IEC 60050-(826), 05-06**]

3.31 overload (of a circuit) time/current relationship in a circuit which is in excess of the rated full load of the circuit when the circuit is not under a fault condition

NOTE : "Overload" should not be used as a synonym for overcurrent.

3.32 plug/socket combination plug and socket-outlet, cable coupler, or appliance coupler

3.33 power circuit circuit used for supplying power from the supply network to units of electrical equipment used for productive operation and to transformers supplying control circuits

3.34 protective bonding circuit the whole of the protective conductors and conductive parts used for protection against electric shock in the event of an insulation failure

3.35 protective conductor conductor required by some measures for protection against electric shock for electrically connecting any of the following parts (**IEV 826-04-05**, modified):

— exposed-conductive-parts;

— extraneous-conductive-parts;

— main earthing terminal.

3.36 reference designation distinctive code which serves to identify an item in a diagram, list or chart, and on the equipment

3.37 risk combination of the probability and the degree of possible injury or damage to health in a hazardous situation (**ISO 12100-1**)

3.38 safe working procedure method of working that reduces risk

3.39 safeguard guard or protective device used as a means to protect persons from a present or impending hazard

3.40 safeguarding safety measures consisting of the use of specific means called safeguards (guard, safety device) to protect persons from hazards that cannot reasonably be removed or are not sufficiently limited by design

3.41 servicing level level on which persons normally stand when operating or maintaining the electrical equipment

3.42 short-circuit current overcurrent resulting from a short circuit due to a fault or an incorrect connection in an electric circuit [see **IEC 60050-(441), 11-07**]

3.43 supplier entity (e.g. manufacturer, contractor, installer, integrator) who provides equipment or services associated with the machine

NOTE : The user may also act in the capacity of a supplier to himself.

3.44 switching device device designed to make or break the current in one or more electric circuits [see **IEC 60050-(441), 14-01**]

NOTE : A switching device may perform one or both of these actions.

3.45 terminal conductive part of a device provided for electrical connection to external circuits

3.46 user entity who utilizes the machine and its associated electrical equipment

4 General requirements

4.1 General considerations This part of **JIS B 9960** is intended to apply to electrical equipment used with a wide variety of machines and with a group of machines working together in a coordinated manner.

The risks associated with the hazards relevant to the HV equipment shall be assessed as part of the overall requirements for risk assessment of the machine. This will determine the acceptable level of risk, and the necessary protective measures for persons who can be exposed to those hazards, while still maintaining an acceptable level of performance of the machine and its equipment.

Hazards can result from, but are not limited to, the following causes:

— failures or faults in the electrical equipment resulting in the possibility of electric shock or electrical fire;

— failures or faults in control circuits (or components and devices associated with those circuits) resulting in the malfunctioning of the machine;

— disturbances or disruptions in power sources as well as failures or faults in the power circuits resulting in the malfunctioning of the machine;

— loss of continuity of circuits that depend upon sliding or rolling contacts, resulting in a failure of a safety function;

— electrical disturbances (e.g. electromagnetic, electrostatic or radio interference) either from outside the electrical equipment or internally generated;

— stored energy (either electrical or mechanical);

— audible noise at levels that cause health problems to persons.

Safety measures are a combination of the measures incorporated at the design stage and those measures required to be implemented by the user.

Design and development shall be the first consideration in the reduction of risks. Where this is not sufficient, safeguarding and safe working procedures shall be considered. Safeguarding includes the use of safeguards and awareness means.

The use of the inquiry form as shown in annex B of this Standard is recommended in order to facilitate an appropriate agreement between the user and the supplier(s) on basic conditions and additional user requirements related to the HV equipment. Those additional requirements are to

— provide additional features that are dependent on the type of machine (or group of machines) and the application;

— facilitate maintenance and repair, and

— advance the reliability and ease of operation.

4.2 Selection of electrical equipment Electrical components and devices shall be suitable for their intended use and shall conform to relevant **JIS** or **IEC** standards where such exist. For example, where factory-built, type-tested HV switchgear is used, it shall be selected from those manufactured and tested in accordance with standards such as **IEC 60298**, **IEC 60466** and **IEC 60694**.

Information : **JEM 1425** specifies as equivalent to **IEC 60298**.

4.3 Electrical supply

4.3.1 General The electrical equipment shall be designed to operate correctly with any of the following supply

— a.c. supply source specified in **4.3.2**;

— a.c. or d.c. source otherwise specified by the user (see annex B), or

— a special source, such as an on-board generator, specified by the supplier.

4.3.2 Supplies

Voltage	Steady-state voltage: 0.9 ... 1.1 of nominal voltage
Frequency	0.99 ... 1.01 of nominal frequency (continuously) or 0.98 ... 1.02 (short time). NOTE : The short-time value may be specified by the user (see annex B).
Harmonics	Harmonic distortion not to exceed 10 % of the total r.m.s. voltage between live conductors for the sum of the 2nd through 5th harmonic. An additional 2 % of the total r.m.s. voltage between live conductors for the sum of the 6th through 30th harmonic is permissible.
Voltage unbalance	Neither the voltage of the negative sequence component nor the voltage of the zero sequence component in three-phase supplies shall exceed 2 % of the positive sequence component.
Voltage interruption	Supply interrupted or at zero voltage for not more than 3 ms at any random time in the supply cycle. There shall be more than 1 s between successive interruptions.
Voltage dips	Voltage dips shall not exceed 20 % of the peak voltage of the supply for more than 1 cycle. There shall be more than 1 s between successive dips.

4.3.3 On-board power supply For special supply systems such as on-board generators, the limits given in **4.3.2** may be exceeded provided that the electrical equipment is designed to operate correctly with those conditions.

4.4 Physical environment and operating conditions The HV equipment shall be suitable for use in the physical environment and operating conditions specified in **4.4.2** to **4.4.8** of **JIS B 9960-1**. When the physical environment or the operating conditions are outside those specified, an agreement may be needed between the supplier and the user (see annex B).

4.5 Transportation and storage Electrical equipment shall be designed to withstand, or suitable precautions shall be taken to protect against, the effects of transportation and storage temperatures within a range of −25 °C to +55 °C and for short periods not exceeding 24 h at up to +70 °C. Suitable means shall be provided to prevent damage from humidity, vibration, and shock.

NOTE : Electrical equipment susceptible to damage at low temperatures includes PVC insulated cables.

4.6 Provisions for handling Heavy and bulky electrical equipment that has to be removed from the machine for transport, or that is independent of the machine, shall be provided with suitable means for handling by cranes or similar equipment (see also **14.5**).

4.7 Installation Electrical equipment shall be installed in accordance with the supplier's instructions, and ergonomic principles should be taken into account.

5 Incoming supply conductor terminations, devices for disconnecting and switching off, and means for earthing

5.1 Incoming supply conductor terminations All terminations for the incoming supply connection shall be clearly identified in accordance with **JIS C 0445**.

5.2 Supply disconnecting (isolating) devices and means for earthing

5.2.1 General A supply disconnecting device shall be provided:

- for each incoming source of supply to a machine;
- for the source of supply to a feeder system, using conductor wires, conductor bars, slip-ring assemblies or flexible cable systems (reeled, festooned), to a machine or a number of machines;
- for each on-board power supply.

The supply disconnecting device shall disconnect (isolate) the electrical equipment of the machine from the supply when required (e.g. for work on the machine).

When two or more supply disconnecting devices are provided, protective interlocks for their correct operation shall be used where a hazardous condition or damage to the machine or to the work in progress can occur.

For each incoming HV supply, means shall be provided to earth and short-circuit all live conductors by connecting them to the earthing system (e.g. for work on the HV equipment).

5.2.2 Type The supply disconnecting device shall be one of the following types:

a) a switch-disconnector, with or without fuses;

b) a disconnecting device that is interlocked to ensure that it cannot be operated until an associated switching device has opened the load circuit;

c) a plug and socket-outlet or an appliance coupler (see **3.32**) for a flexible cable supply (e.g. reeled, festooned) to a mobile machine under the following conditions:

   - it shall not be possible to connect or disconnect a plug and socket-outlet or an appliance coupler having no breaking capacity during load conditions. The effects of charging currents shall be taken into account;
   - the plug and socket-outlet or the appliance coupler shall be so connected that the part connected to the incoming power supply is that which is protected to at least IP2XH or IPXXBH, when located inside an enclosed electrical operating area, or to at least IP4XH or IPXXDH when located outside an enclosed electrical operating area.

When used, earthing switches shall be constructed and selected in accordance with **JIS C 4606**. It is recommended that the supply disconnecting device and the associated earthing switch be combined in a functional unit (see **3.104** of **IEC 60298**). When not assembled with the associated disconnecting device in accordance with **IEC 60298** or **IEC 60466**, there shall be interlocks which ensure that

— closing and opening of the earthing switch is only possible when the disconnecting device is in the open position, and

— closing and opening of the disconnecting device is only possible when the earthing switch is in the open position.

Information : For the said requirements **JEM 1425** is equivalent to **IEC 60298**.

5.2.3 Requirements

5.2.3.1 Disconnecting (isolating) device When the supply disconnecting device is one of the types specified in **5.2.2 a**) or **5.2.2 b**) it shall fulfil all of the following requirements:

— isolate the electrical equipment from the HV supply and have one OFF (isolated) and one ON position only, clearly marked with "O" and "I" (symbols **IEC-60417-5008** and **IEC-60417-5007**, see **10.2.2** of **JIS B 9960-1**), with the actuating directions in accordance with **JIS B 9706-3**;

— have a visible gap or a position indicator which cannot indicate OFF (isolated) until all contacts are actually open and adequate isolating distances are ensured;

— be provided with a means permitting it to be locked in the OFF (isolated) position (e.g. by padlocks). When so locked, local as well as remote closing shall be prevented;

— disconnect all live conductors of its power supply circuit;

— have a breaking capacity sufficient to interrupt the current of the largest motor when stalled together with the sum of the normal running currents of all other motors and/or loads. The calculated breaking capacity may be reduced by the use of a proven diversity factor.

Where an external operating means (e.g. handle) is provided it should be BLACK or GREY, excepting emergency devices (see **10.7** of **JIS B 9960-1**).

5.2.3.2 Means for earthing and short-circuiting The means for earthing shall be capable of withstanding the prospective short-circuit current of the supply. When used, an earthing switch shall

— have a reliable position indicator;

— have an external handle for the earthing function (this can be the handle also used for operating the disconnecting device);

— earth and short-circuit all live conductors to the earthing system;

— be provided with means permitting it to be locked in the ON position and, if required (see annex B, question 16), in the OFF position, preferably by padlocks.

When an associated circuit-breaker is used for short-circuiting and for earthing and is locked in the closed (and earthed) position, local as well as remote opening shall be prevented.

5.2.4 Operating handle When provided, the handle(s) of the supply disconnecting device and of the earthing switch shall be easily accessible and should be located between 0.6 m and 1.9 m above the servicing level.

5.3 Devices for switching off for prevention of unexpected start-up Devices for switching off for the prevention of unexpected start-up shall be provided (e.g. where, during maintenance, a start-up of the machine can create a hazard). Devices described in **5.2.2** may fulfil that function. Disconnectors, withdrawable fuse links or withdrawable links may also be used for that purpose, but only when located in an enclosed electrical operating area (see **3.12**).

Such devices shall be appropriate and convenient for the intended use, shall be suitably placed, and readily identifiable (e.g. by a durable marking where necessary).

Means shall be provided to prevent inadvertent, and/or mistaken closure of the disconnecting device (see also **5.5**).

When means other than supply disconnecting devices in accordance with **5.2.2** are used (e.g. an electromagnetic contactor or circuit-breaker switched off by a control circuit), such means for switching off are intended to be employed only for situations

— no significant dismantling of the machine;

— adjustments requiring a relatively short time;

— no work being carried out on or near the HV parts of the electrical equipment.

5.4 Devices for disconnecting and means for earthing HV equipment Devices for disconnecting (isolating) and means for earthing HV equipment shall be provided to enable work to be carried out without a risk from electric shock or burn.

The supply disconnecting device together with a means for earthing the relevant circuit (see **5.2**) may fulfil these functions. However, where it is necessary to work on individual HV part(s) of the electrical equipment of a machine, or on one of a number of machines fed by a common conductor bar or conductor wire system, a disconnecting device together with a means for earthing shall be provided for each part, or for each machine, requiring separate isolation and earthing. Where HV capacitors are part of the electrical equipment, discharging means shall be provided.

Devices described in **5.2** may fulfil these functions. Other means of isolation such as disconnectors, withdrawable fuse links or withdrawable links, together with a means for earthing, may also be used for that purpose, but only when located in an enclosed electrical operating area. Such disconnecting devices and means for earthing shall be

— appropriate and convenient for the intended use;

— suitably located;

— readily identifiable as to which HV part or HV circuit(s) of the electrical equipment is served (e.g. by durable marking where necessary);

— provided with adequate means to prevent unauthorized, inadvertent, and/or mistaken closure of the disconnecting devices and opening of the means for earthing (see **5.5**).

Electrical equipment such as HV transformers or HV capacitors shall be provided with additional means of earthing and short-circuiting adjacent to that electrical equipment, except where it is located in the immediate vicinity of the associated switchgear.

Information : For the case where the HV equipment is part of a power installation, requirements are given in **7.3** of **HD 637**.

5.5 Protection against unauthorized, inadvertent and/or mistaken operation The devices for disconnecting (isolating) and means for earthing described in **5.3** and **5.4** that are capable of being equipped with means to lock them in the OFF position or disconnected state or earthed condition (e.g. by padlocks) in order to achieve protection against unauthorized, inadvertent, and/or mistaken operation shall be equipped with such means. Other means of protection against such operation (e.g. warning labels) may be used where the non-lockable means are located in an enclosed electrical operating area.

However, when a device according to **5.2.2 c**) (e.g. plug/socket combination) and/or a means for earthing is so positioned that it can be under the immediate supervision of the person carrying out the work, means for locking need not be provided.

6 Protection against electric shock

6.1 General The HV parts of the electrical equipment shall provide protection of persons against electric shock from

— direct contact;

— indirect contact.

The recommended measures for this protection are given in **6.2** and **6.3**, which are derived from **JIS C 0364-4-41**.

Information : Where those recommended measures are not practicable, other measures from **HD 637** may be used.

6.2 Protection against direct contact Protection against direct contact with live parts, parts with insulation for functional purposes only and with parts which can be considered to have a hazardous potential (examples of such parts are shown in **7.1.1** of **HD 637**) shall be provided as follows:

a) **Installations outside enclosed electrical operating areas** Protection against direct contact shall be provided by enclosures with a minimum degree of protection of IPXXDH (see **JIS C 0920**).

b) **Installations inside enclosed electrical operating areas** Protection against direct contact shall be provided by enclosures or doors or mesh-grids or barriers to a minimum degree of protection of IPXXAH (see **JIS C 0920**).

Information : For dimensions of doors, mesh-grips and barriers and clearances to live parts, specifications are given in **6.3** of **HD 637**.

Access to HV parts of the electrical equipment shall only be possible by the use of a key or tool.

NOTE : For protective measures for conductor wires, conductor bars and slip-ring assemblies, see **13.8.1**.

Information : Where these measures are not practicable, other measures for protection against direct contact (e.g. by placing out of reach, using obstacles) as specified in **7.1** of **HD 637** may be used.

6.3 Protection against indirect contact

6.3.1 General Protection against indirect contact is intended to prevent hazardous conditions in the event of an insulation failure between live parts and exposed-conductive-parts.

For each HV circuit or HV part of the electrical equipment, at least one of the measures in accordance with **6.3.2** to **6.3.3** shall be applied.

Protection against indirect contact can be achieved

— by measures to prevent the occurrence of a touch voltage which exceeds the tolerable touch voltage for an unlimited time of fault duration, or

— for a higher touch voltage, which is not hazardous for a limited time of fault duration, by automatic disconnection of the supply within that time.

These measures necessitate coordination between

— the type of supply and earthing system;

— the impedance values of the different elements of the protective bonding circuit, and

— the characteristics of the devices used to detect insulation failure.

6.3.2 Measures to prevent the occurrence of a hazardous touch voltage for an unlimited time of fault duration Measures to prevent the occurrence of a hazardous touch voltage for an unlimited time of fault duration include the following:

It is recommended that a supply system which is isolated from earth, or is designed with its neutral point having a high impedance to earth, is used. An earth fault detection device should be provided to initiate an alarm when an earth fault is detected.

NOTE : Supply systems isolated from earth include systems without a neutral point such as single-phase systems, delta connected systems and d.c. systems.

Information : Selection or design of the supply system and neutral earthing is described in **3.1** of **HD 637**, and design of the earthing system, in clause **9** of **HD 637**.

6.3.3 Protection by automatic disconnection of supply within a limited time of fault duration Automatic disconnection of the supply of any circuit affected by the occurrence of an insulation failure within a limited time is intended to prevent a hazardous condition resulting from a touch voltage higher than the tolerable touch voltage for an unlimited time of fault duration.

This protective measure comprises both

— the connection of exposed-conductive-parts to the protective bonding circuit (see clause **8**), and

— either

a) the use of devices for the automatic disconnection of the supply in the event of an insulation failure in a supply system with low-impedance neutral earthing or direct neutral earthing, or

b) the use of earth fault detection to initiate automatic disconnection of a supply system isolated from earth or designed with its neutral point having a high impedance to earth.

The selection/setting of the device(s) shall be such as to ensure that automatic disconnection of the supply takes place before the touch voltage, arising from an insulation failure, becomes hazardous.

Information : For hazardous touch voltages, specification is given in clause **9** of **HD 637**.

6.3.4 Protection for mobile machines The measures described in **6.3.2** and **6.3.3** shall be selected by taking the following into consideration:

— system voltage;

— length of supply cable;

— number of machines connected to the point of supply;

— type of supply cable;

— type of neutral earthing;

— value of earth-fault current in a supply system with low impedance neutral earthing.

General limitations depending upon the type of supply system are given below:

— direct neutral earthing is generally only appropriate for system voltages less than 2 kV. Automatic disconnection is always required;

— low impedance neutral earthing may be appropriate for system voltages up to 36 kV and a cable length up to 4 km. Automatic disconnection is normally necessary;

— isolated neutral earthing or high impedance neutral earthing is appropriate for system voltages up to 36 kV and a cable length up to 8 km (this length depends upon the capacitive reactance of all cables connected to the supply). Automatic disconnection is normally not necessary.

7 Protection of HV equipment

7.1 General Clause **7** details the measures to be taken to protect HV parts of the electrical equipment against the effects of

— overcurrent (**7.2**);

— earth fault (**7.3**);

— overvoltage due to lightning and switching surges (**7.4**);

— other abnormal conditions (**7.5**).

JIS B 9960-1 details measures to be taken to protect equipment against the effects of

— overload current of motors (see **7.3** of **JIS B 9960-1**);

— loss of or reduction in the supply voltage (see **7.5** of **JIS B 9960-1**);

— overspeed of machines/machine elements (see **7.6** of **JIS B 9960-1**);

— incorrect phase sequence (see **7.8** of **JIS B 9960-1**).

7.2 Overcurrent protection

7.2.1 General Overcurrent protection shall be provided where the current in a machine circuit can exceed either the rating of any component or the current-carrying capacity of the conductors, whichever is the lesser value. The ratings or settings to be used are detailed in **7.2.6**.

7.2.2 Supply conductors Unless otherwise specified by the user, the supplier of the HV equipment shall not be responsible for providing the overcurrent protective device for the supply conductors to the HV equipment.

The supplier of the HV equipment shall state on the installation diagram the data necessary for selecting the overcurrent protective device (see **7.2.6** of this Standard and **18.5** of **JIS B 9960-1**, see also annex B, question 15).

7.2.3 Power circuits Devices for detection and interruption of overcurrent, selected in accordance with **7.2.6**, shall be applied to each live conductor.

7.2.4 Transformers Transformers shall be protected against overcurrent in accordance with **IEC 60076-5**. Such protection shall (see **7.2.6**).

— avoid nuisance tripping due to transformer magnetizing inrush currents;

— avoid a winding temperature rise in excess of the permitted value for the insulation class of transformer when it is subjected to the effects of a short circuit at its secondary terminals.

The type and setting of the overcurrent protective device should be in accordance with the recommendations of the transformer supplier.

For the provision of protection against other abnormal conditions, see **7.5**.

7.2.5 Overcurrent protective devices The rated short-circuit breaking capacity shall be at least equal to the prospective fault current at the point of installation. Where the short-circuit current to an overcurrent protective device can include additional currents other than from the supply (e.g. from motors, from power factor correction capacitors), those currents shall be taken into consideration.

Overcurrent protective devices for power circuits include fuses and circuit-breakers.

7.2.6 Rating and setting of overcurrent protective devices The rated current of fuses or the setting current of other overcurrent protective devices shall be selected as low as possible but adequate for the anticipated overcurrents (e.g. during starting of motors or energizing of transformers). When selecting those protective devices, consideration should be given to the protection of switching devices against damage due to overcurrents (e.g. welding of the switching device contacts).

The rated current or setting of an overcurrent protective device is determined by the current-carrying capacity of the conductors to be protected by that device in accordance with **13.4**. That should take into account the needs of coordination with other electrical devices in the protected circuit. The recommendations of the supplier of those devices should be followed.

7.3 Earth fault protection Earth fault protection shall be provided as described below when the earth-fault current can be lower than the setting of the overcurrent protective devices and unacceptable damage to the electrical equipment can occur.

An earth fault monitoring system that is appropriate to the type of HV supply system in use (e.g. system isolated from earth, direct neutral earthed system) shall be provided. The electrical equipment or the appropriate section of the electrical equipment shall be switched off if the earth fault exceeds a given current/time value.

The setting of the earth fault protective devices shall be as low as possible and consistent with proper operation of the electrical equipment.

Unless otherwise specified by the user, the supplier of the HV equipment is not responsible for providing the earth fault protective device for the HV supply conductors. The supplier of the HV equipment shall state on the installation diagram the data necessary for selecting the earth fault protective device (see **7.2.6** of this Standard and **18.5** of **JIS B 9960-1**) (see annex B).

7.4 Protection against overvoltages due to lightning and to switching surges Protective devices can be provided to protect against the effects of overvoltages due to lightning or to switching surges. These devices include, for example, arrester, surge absorber.

Devices for the suppression of overvoltages due to switching surges shall be connected across the HV terminals of all electrical equipment requiring such protection.

7.5 Protection against other abnormal conditions Protection against conditions such as abnormal temperature, overpressure and leakage shall be provided on liquid-filled HV equipment such as transformers, reactors and switchgear as necessary, to prevent the occurrence of a hazardous situation.

Information : **HD 637**, **7.6** describes the related matters.

8 Equipotential bonding

8.1 General This clause 8 gives requirements for the equipotential bonding of

— the exposed-conductive-parts of the electrical equipment,

— the extraneous-conductive-parts of the machine, and

— the earthing system,

and for supplementary equipotential bonding (see **8.2.7**) as required, in order to ensure protection against indirect contact. Figure 2 illustrates these concepts.

Information : The use of the terms related to earthing and protective bonding in this part of **JIS B 9960** is different in some respects to their use in **HD 637** (see annex E).

8.2 Protective bonding circuit

8.2.1 General The protective bonding circuit consists of (see figure 2)

— the machine bonding conductor(s);

— the protective conductors of the electrical equipment of the machine (including sliding contacts where they are part of the circuit); and

— the equipotential bonding conductors connected to the structural parts of the electrical equipment and to the structural parts of the machine (equipotential bonding on the machine).

On mobile machines with on-board power supplies, the protective bonding circuits, the exposed-conductive-parts, and the extraneous-conductive-parts shall all be connected to a protective bonding terminal to provide protection against electric shock. When a mobile machine is also capable of being connected to an external incoming supply, the protective bonding terminal shall be the connection point for the external protective conductor.

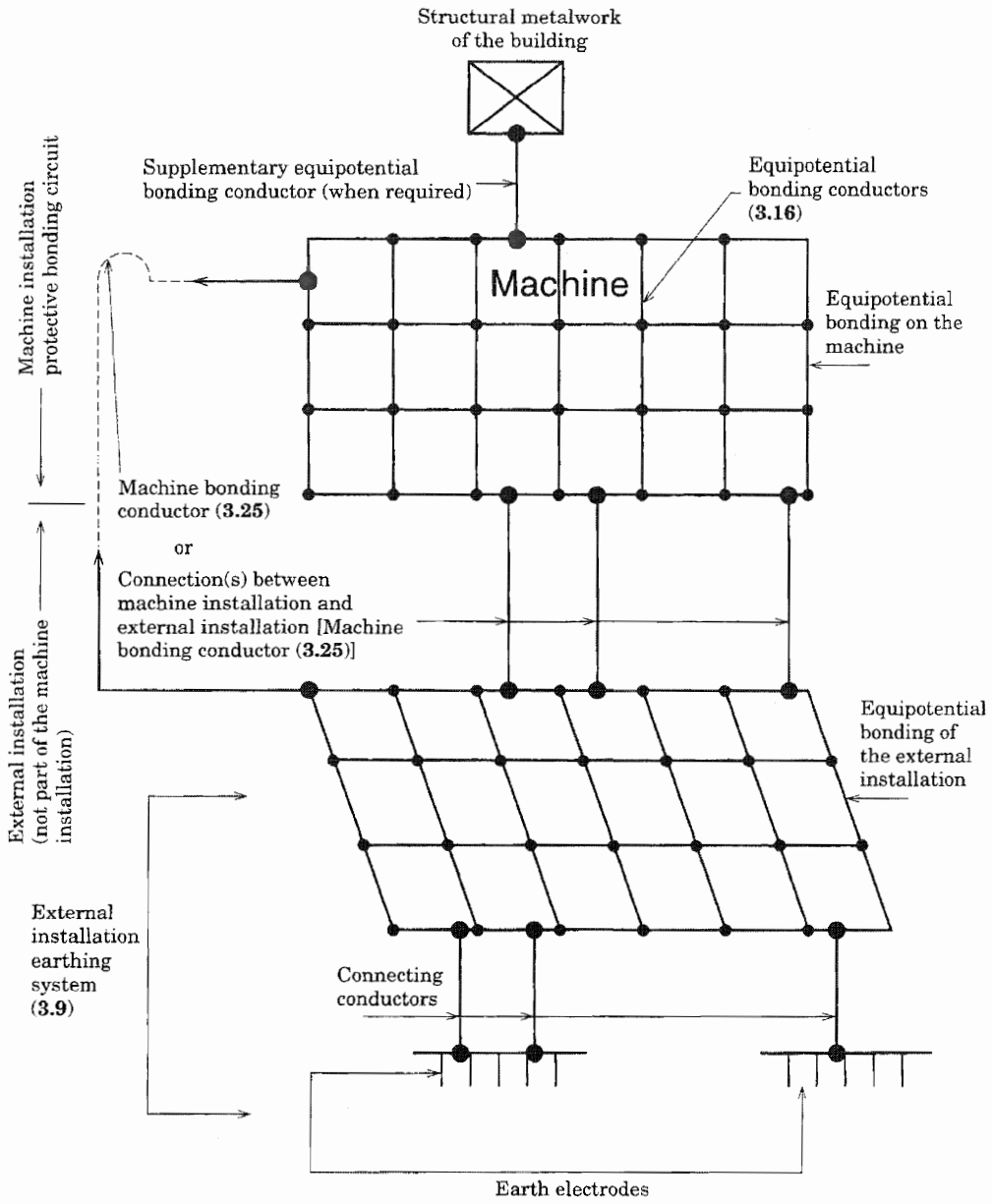
NOTE : When the supply of electrical energy is self-contained within stationary, mobile, or movable items of machinery, and when there is no external supply connected (e.g. when an on-board battery charger is not connected), there is no need to connect such electrical equipment to an external protective conductor.

All parts of the interconnected protective bonding circuits for the HV equipment and the LV equipment shall be so designed that they are capable of withstanding the highest thermal and mechanical stresses that can be caused by earth-fault currents that could flow in any part of the protective bonding circuits.

Information : Details on how to fulfil this requirement are given in **9.4** of **HD 637**.

The structural parts of the machine shall be individually connected to the protective bonding circuit.

Any structural part of the electrical equipment or of the machine may be used as part of the protective bonding circuit provided that it satisfies the requirements of **JIS C 0364-5-54**.



NOTES 1 The protective conductors of the electrical equipment of the machine are not shown (see figure 3 of **JIS B 9960-1**).

2 Numbers in parentheses refer to subclauses in this Standard.

Figure 2 Example of the equipotential bonding (see 3.15) for electrical equipment of a machine

8.2.2 Protective conductors Protective conductors shall be identified in accordance with **14.2**.

Copper conductors should be used. Where a conductor material other than copper is used, the electrical resistance per unit length shall not exceed that of the allowable

copper conductor. The conductor material shall be selected taking into account the possible effects of corrosion.

The cross-sectional area S of a bare protective conductor shall be at least that given in table 1.

Information : Where the connection of the machine to an external installation earthing system using such a value is not sufficient to provide protection against indirect contact. **9.2** of **HD 637** specifies the requirement for the cross-sectional area S of the bare conductor.

Table 1 Cross-sectional area of bare protective conductors

Requirements	S (mm^2)
Mechanical strength	S_{min} = 16 mm^2 for copper = 35 mm^2 for aluminium = 50 mm^2 for galvanized steel
Thermal stress due to continuous earth-fault current $I_E \leq 100$ A	
Thermal stress due to continuous earth-fault current $I_E > 100$ A	$S = S_{min}\ (I_E/100)^2$
Thermal stress due to short-time earth-fault current up to 5 s	See annex C
NOTE: S_{min} for mechanical strength is also sufficient for a continuous earth-fault current up to 100 A for bare conductors, based on the maximum allowable touchable temperature of 80 °C in accordance with table 42A of **JIS C 0364-4-42**.	

8.2.3 Continuity of the protective bonding circuit All exposed-conductive-parts of the electrical equipment and the machine(s) shall be connected to the protective bonding circuit. Where a part is removed for any reason (e.g. routine maintenance), the protective bonding circuit for the remaining parts shall not be interrupted.

Connection and bonding points shall be so designed that their current-carrying capacity is not impaired by mechanical, chemical, or electrochemical influences. Where enclosures and conductors of aluminium or aluminium alloys are used, particular consideration should be given to the problems of electrolytic corrosion.

Metal ducts of flexible or rigid construction and metallic cable sheaths shall not be used as protective conductors. Nevertheless, such metal ducts and the metal sheathing of all connecting cables (e.g. cable armouring, lead sheath) shall be connected to the protective bonding circuit.

Doors, lids or cover plates on which devices (e.g. operator interface devices) are mounted shall be connected to the protective bonding circuit by a protective conductor.

For machines, for example mobile machines, where the connection to the earthing system (machine bonding conductor) is provided solely by flexible cables, the continuity of the protective conductor shall be assured by appropriate design of the cable (see **13.7**). Where there is a possibility that the cable and hence the machine bonding conductor could become damaged (e.g. a trailing cable dragged on the ground), the continuity of the protective bonding circuit shall be monitored (see question 13 in annex B). The HV supply to the electrical equipment of the machine or to the relevant part of the machine shall be switched off

— when loss of continuity of the protective bonding circuit is detected, or

— when failure of the monitoring means occurs.

For requirements for the continuity of the protective bonding circuit using conductor wires, conductor bars and slip-ring assemblies, see **13.8.2**.

8.2.4 Exclusion of switching devices from the protective bonding circuit The protective bonding circuit shall not incorporate a switching device, an overcurrent protective device (e.g. switch, fuse) or a means for current detection for such devices.

NOTE : It is permissible to include devices that do not interrupt the protective bonding circuit, that have electrical characteristics that under all circumstances ensure prevention of a hazardous voltage rise in any part of the circuit, and that do not impair the performance of the circuit.

8.2.5 Interruption of the protective bonding circuit Where the continuity of the protective bonding circuit can be interrupted by means of removable current collectors or plug/socket combinations, the protective bonding circuit shall not be interrupted before the live conductors have been disconnected, and shall be re-established before any live conductor is reconnected. This also applies to removable or withdrawable plug-in units (see also **14.4**).

Metallic housings of plug/socket combinations shall be connected to the protective bonding circuit.

8.2.6 Protective bonding circuit connecting points All protective conductors shall be terminated in accordance with **14.1.1**. The protective conductor connecting points shall have no other function and shall not be used, for example, to mechanically attach or connect appliances or parts.

Each connecting point for

— protective conductors inside the electrical equipment of the machine (see **JIS B 9960-1**, figure 3).

— the equipotential bonding conductors on the machine (see figure 2),

— the machine bonding conductor(s) (see figure 2),

shall be identified as such using the symbol **IEC-60417-5019**:

Graphical symbol **IEC-60417-5019**

8.2.7 Supplementary equipotential bonding conductors Supplementary equipotential bonding conductors shall be used to connect the protective bonding circuit of the machine to the structural metalwork of the building when such metalwork is in close proximity (e.g. less than 2.5 m) to the machine. These conductors shall conform to **547.1.2** of **JIS C 0364-5-54** as appropriate. The cross-sectional area of a supplementary equipotential bonding conductor shall be not less than half the cross-sectional area of the associated machine bonding conductor and shall be not less than that specified in **8.2.2**.

9 Control circuits and control functions The requirements of clause **9** of **JIS C 9960-1** apply except where the LV control circuits are covered by other standards. Control circuits directly connected to high-voltage circuits (e.g. thyristor gate circuits) shall be electrically separated from low voltage circuits by the use of an interface technique such as optical coupling or transformer coupling.

10 Operator interface and machine-mounted control devices The requirements of clause **10** of **JIS C 9960-1** apply, but the minimum degree of protection against direct contact shall be IPXXDH for operator interface and machine-mounted control devices (see also **6.2**).

11 Electronic equipment The requirements of clause **11** of **JIS C 9960-1** apply.

Information : Basic requirements for power electronic equipment are covered by **EN 50178** and requirements for static converters are covered by **5.2.12** of **HD 637**.

12 Controlgear: location, mounting, and enclosures

12.1 General requirements All controlgear shall be located and mounted so as to facilitate

— its accessibility and maintenance;

— its protection against the external influences or conditions under which it is intended to operate;

— operation and maintenance of the machine and its associated electrical equipment.

12.2 Location and mounting

12.2.1 Accessibility and maintenance All items of controlgear shall be so placed and oriented that they can be identified without moving them or the wiring. For items that require checking for correct operation or that are liable to need replacement, these actions should be possible without dismantling other electrical equipment or parts of the machine (except opening doors or removing covers). Terminals not associated with controlgear shall also conform to these requirements.

All controlgear shall be mounted so as to facilitate its operation and maintenance from the front. Where a special tool is necessary to remove a device, such a tool shall be supplied. Where access is required for regular maintenance or adjustment, the relevant devices should be located between 0.4 m and 2 m above the servicing level. It is recommended that terminals be at least 0.2 m above the servicing level and be so placed that conductors and cables can be easily connected to them.

Only those devices necessary for operator interface purposes (for example operation, indication, measurement) and for cooling may be mounted on doors and on normally removable access covers of enclosures.

Where control devices are connected through plug-in arrangements, their association shall be made clear by type (shape), marking or reference designation (see **14.4.5** of **JIS B 9960-1**).

Test points, where provided, shall be

— mounted so as to provide unobstructed access;

— clearly marked to correspond with the documentation (see **18.3** of **JIS B 9960-1**);

— adequately insulated;

— sufficiently spaced for connection of the test equipment or means.

12.2.2 Physical separation Enclosures containing HV equipment shall not contain LV equipment and non-electrical parts except where they form an integral part of the HV equipment and are essential for its correct operation.

HV switchgear adjacent to LV equipment shall be metal-enclosed and capable of withstanding an internal arc-fault, and distinguishable from LV equipment by clear marking.

When arranging the location of devices (including interconnections), the clearances and creepage distances specified for them shall be maintained, taking into account the external influences or conditions of the physical environment (see **IEC 60071-1** and **IEC 60071-2**).

12.3 Degrees of protection The protection of controlgear against ingress of solid foreign objects and of liquids shall be adequate taking into account the external influences under which the machine is intended to operate (i.e. the location and the physical environmental conditions) and shall be sufficient against dust, coolants, and swarf.

NOTE 1 The degrees of protection against ingress of water are covered by **JIS C 0920**. Additional protective measures may be necessary against other liquids.

Enclosures of controlgear shall provide a degree of protection of at least IP22 (see **JIS C 0920**). Excepting the case where an electrical operating area is used as a protective enclosure for an appropriate degree of protection against the ingress of solid bodies and liquids.

NOTES 2 Other degrees of protection may be needed for protection against electric shock (see clause **6**).

3 Some examples of typical degree of protection for enclosures, are listed below:

— ventilated enclosure, containing only motor starter resistor and other large size electrical equipment: IP10;

— ventilated enclosure, containing other electrical equipment: IP32;

— enclosure used in general industry: IP32, IP43 and IP54;

— enclosure used in locations that are cleaned with low pressure water jets (hosing): IP55;

— enclosure providing protection against fine dust: IP65;

— enclosure containing slip ring assemblies: IP2X.

Depending upon the installation conditions, another degree of protection may be appropriate.

12.4 Enclosures, doors and openings Enclosures shall be constructed using materials capable of withstanding the mechanical, electrical and thermal stresses as well as the effects of humidity that are likely to be encountered in normal service.

Fasteners used to secure doors and covers should be of the captive type. Inspection windows shall be of a material suitable to withstand chemical attack and mechanical stress comparable to that of the enclosure. Precautions shall be taken to prevent the formation of a static charge on the windows, which may lead to a hazardous situation, either by adequate clearances or electrostatic shielding (e.g. wire mesh placed on the inside of the window and bonded to the enclosure).

It is recommended that enclosure doors should have vertical hinges, preferably of the lift-off type, with an angle of opening of at least 95° (stoppered).

The joints or gaskets of doors, lids, covers and enclosures shall withstand the chemical effects of the aggressive liquids, vapours, or gases used on the machine. The means used to maintain the degree of protection of an enclosure on doors, lids, and covers that require opening or removal for operation or maintenance shall

— be securely attached to either the door/cover or the enclosure;

— not deteriorate due to removal or replacement of the door or the cover, and so impair the degree of protection.

All openings in the enclosure, including those towards the floor or foundation or to other parts of the machine, shall be closed by the supplier(s) in a manner ensuring the degree of protection specified for the electrical equipment. Openings for cable entries shall be easily re-opened on site. A suitable opening may be provided in the base of enclosures within the machine so that moisture due to condensation may drain away.

There shall be no opening between enclosures containing electrical equipment and compartments containing coolant, lubricating or hydraulic fluids, or those into which oil, other liquids, or dust can penetrate. This requirement does not apply to electrical devices specifically designed to operate in oil (e.g. electromagnetic clutches) nor to electrical equipment in which coolants are used.

Where there are holes in an enclosure for mounting purposes, care shall be taken so that after mounting, the holes do not impair the required protection.

Electrical equipment that, in normal or abnormal operation, can attain a high surface temperature

— shall be located within an enclosure that will withstand such temperatures as may be generated, and

— shall be mounted and located at a sufficient distance from adjacent equipment so as to allow safe dissipation of heat (see **12.2.3** of **JIS B 9960-1**), or shall be otherwise screened by material that can withstand the heat emitted by the electrical equipment.

12.5 Access to HV equipment For access to HV equipment, **6.5** of **HD 637** may be referred to.

Information : **6.5** of **HD 637** consists of the following subclauses;

6.5 Requirements for buildings, **6.5.1** Foreward, **6.5.2** Construction, **6.5.2.1** Summary, **6.5.2.2** Wall, **6.5.2.3** Window, **6.5.2.4** Roof, **6.5.2.5** Floor, **6.5.3** Switchgear station, **6.5.4** Service area, **6.5.5** Door, **6.5.6** Draining of dielectric fluid, **6.5.7** Air-conditioning and ventilation, **6.5.8** Structures requiring particular care.

13 Conductors and cables

13.1 General requirements Conductors and cables shall be so selected as to be suitable for the operating conditions (e.g. voltage, current, presence of harmonics, protection against electric shock, grouping of cables and method of laying) and the external influences (e.g. ambient temperature, presence of water or corrosive substances, mechanical stresses (including stresses during installation), fire hazards that can exist.

In supply systems with direct or low impedance earthing of the neutral, all types of cable may be used if an earth fault is interrupted within 1 s.

In supply systems with the neutral isolated or resonantly earthed, all types of radial field cable may be used when the estimated duration of any earth fault does not exceed 8 h. Where the estimated duration of any earth fault exceeds 8 h a radial field cable of the next higher voltage rating shall be used (see annex D). The recommendations of the cable supplier should be followed.

These requirements do not apply to the integral wiring of assemblies, which are manufactured and tested in accordance with relevant **JIS** standards.

13.2 Conductors In general, conductors should be of copper. Conductors of another material shall have a nominal cross-sectional area such that, carrying the same current, the maximum conductor temperature shall not exceed the value given in table 2.

Table 2 Maximum allowable conductor temperatures under normal and short-circuit conditions

Unit: °C

Types of insulation	Maximum temperature under normal conditions	Ultimate short-time temperature under short-circuit conditions [a]
Polyvinyl chloride (PVC)	70	160 (< 300 mm²)
Cross-linked polyethylene (XLPE)	90	250
Ethylene-propylene compound (EPR/HEPR)	80 to 90 [b]	250

NOTE: For ultimate short-time conductor temperatures greater than 200 °C, copper conductors shall be either silver-plated or nickel-plated because neither tinned nor bare conductors are suitable above 200 °C.

Information: The electrical appliance Safety Law and **JCS 168** give regulations different from this table.

[a] These values are based on the assumption of adiabatic behaviour for a period of not more than 5 s.

[b] Consultation with the cable manufacturer is required.

To withstand the electrodynamic and thermal effects of short-circuit currents, the dimensions of conductors shall be calculated according to **IEC 60865-1**.

13.3 Insulation and sheath materials The types of insulation and sheath materials include (but are not limited to)

— polyvinyl chloride (PVC);

— cross-linked polyethylene (XLPE);

— ethylene propylene compound (EPR/HEPR).

Where the material of the insulation or the sheath of a cable (e.g. PVC) can constitute hazards due to the propagation of a fire or the emission of toxic or corrosive fumes, guidance should be sought from the cable supplier.

The mechanical strength and thickness of the materials shall be so selected that the insulation and the sheath cannot be damaged in operation or during laying, especially for cables pulled into ducts.

Information : Relevant requirements are given in **5.2.9** of **HV 637**.

13.4 Current-carrying capacity in normal service The current-carrying capacity of conductors and cables is determined by both

— the maximum allowable conductor temperature under the highest possible steady-state current or the thermal equivalent r.m.s. current.

— the ultimate allowable short-time conductor temperature under short-circuit conditions.

The cross-sectional area of a conductor shall be such that, under these conditions, the conductor temperature does not exceed the value given in table 2, unless otherwise specified by the cable supplier.

The cable supplier shall be consulted for details of the current carrying capacities of cables for all continuous duty and intermittent duty applications.

13.5 Conductor and cable voltage drop The voltage drop from the point of supply to the load shall be such that the correct operation of the electrical equipment is not affected by undervoltage. However, the overvoltage during no-load operation shall not damage the electrical equipment.

13.6 Minimum cross-sectional area The cross-sectional areas of the conductors shall be selected according to **13.1** and **8.2.2**.

13.7 Flexible cables

13.7.1 General Cables that are subjected to severe duties shall be of adequate construction to protect against

— abrasion due to mechanical handling and dragging across rough surfaces;

— kinking due to operation without guides;

— stress resulting from guide rollers and forced guiding, being wound and rewound on cable drums.

NOTES 1 Cables for such conditions should follow the supplier's specifications.

2 The operational life of the cable will be reduced where unfavourable operating conditions such as high tensile stress, small radii, bending into another plane and/or frequent duty cycles coincide.

Each flexible cable for the HV power supply for the electrical equipment of a mobile machine shall contain a protective conductor (see **8.2.3**). The cross-sectional area of the protective conductor shall be determined in accordance with clause **8**. If the cross-sectional area is at least 25 mm^2, the protective conductor may be divided into several conductors of equal cross-sectional areas within the flexible cable.

13.7.2 Mechanical rating The cable handling system of the machine shall be designed to keep the tensile stress of the conductors as low as is practicable during machine operations. Where copper conductors are used, the tensile stress shall not exceed 15 N/mm^2 of the copper cross-sectional area. Where the demands of the application exceed the tensile stress limit of 15 N/mm^2, cables with special construction features should be used and the allowed maximal tensile strength should be agreed with the cable manufacturer.

The allowed maximum stress of conductors of flexible cables with material other than copper should be agreed with the cable manufacturer.

NOTE : The following conditions affect the tensile stress of the conductors:

— acceleration forces;

— speed of motion;

— dead (hanging) weight of the cables;

— method of guiding;

— design of cable drum system.

13.7.3 Current-carrying capacity of cables wound on drums Cables to be wound on drums shall be selected with conductors of such cross-sectional area that, when fully wound on the drum and carrying the normal service load, the maximum allowable conductor temperature is not exceeded.

For cables of circular cross-sectional area installed on drums, the maximum current-carrying capacity in free air should be derated in accordance with table 3 (see also clause **44** of **IEC 60621-3**).

NOTE : The current-carrying capacity of cables in free air can be found in manufacturers' specifications.

Table 3 Derating factors for cables wound on drums

Drum type	Number of layers of cable				
	Any number	1	2	3	4
Cylindrical ventilated	—	0.85	0.65	0.45	0.35
Radial ventilated	0.85	—	—	—	—
Radial non-ventilated	0.75	—	—	—	—

NOTES 1 A radial type drum is one where spiral layers of cable are accommodated between closely spaced flanges; if fitted with solid flanges, the drum is described as non-ventilated and if the flanges have suitable apertures, as ventilated.

2 A ventilated cylinder drum is one where the layers of cable are accommodated between widely spaced flanges and the drum and end flanges have ventilating apertures.

3 It is recommended that the use of derating factors be discussed with the cable and the cable drum manufacturers. This may result in other factors being used.

13.8 Conductor wires, conductor bars and slip-ring assemblies

13.8.1 Protection against direct contact Conductor wires, conductor bars and slip-ring assemblies shall be so installed or enclosed that, during normal access to the machine, protection against direct contact shall be achieved by the application of one of the following protective measures:

— protection by enclosures or barriers of at least IPXXDH according to **JIS C 0920** (see also **412.2** of **JIS C 0364-4-41**);

— protection by plating out of reach (see **412.4** of **JIS C 0364-4-41**).

Information : **7.1.2** of **HD 637** details the relevant matters.

Where protection is achieved by placing live parts out of reach, emergency switching off in accordance with **9.2.5.4.3** of **JIS B 9960-1** shall be applied.

Conductor wires and conductor bars shall be so placed and/or protected as to

— prevent contact, especially for unprotected conductor wires and conductor bars, with conductive items such as the cords of pull-cord switches, strain-relief devices and drive chains;

— prevent damage from a swinging load.

13.8.2 Protective bonding circuit Where conductor wires, conductor bars and slip-ring assemblies are installed as part of the protective bonding circuit, they shall not carry current in normal operation.

The continuity of the parts of the protective bonding circuit using sliding contacts shall be ensured by taking appropriate measures (e.g. by duplication of the current collector, continuity monitoring).

13.8.3 Protective conductor current collectors Protective conductor current collectors shall have a shape or construction such that they are not interchangeable with the other current collectors. Such current collectors shall be of the sliding contact type.

13.8.4 Clearances in air Clearances between the respective conductors, and between adjacent systems of conductor wires, conductor bars, slip-ring assemblies and their current collectors shall be suitable for the rated short-duration power frequency withstand voltage and for the lower level of the rated lightning impulse withstand voltage shown in table 2 of **IEC 60071-1**.

Information : Table 1 of **HD 637** also gives the matters related.

13.8.5 Creepage distances Creepage distances between the respective conductors, and between adjacent systems of conductor wires, conductor bars, slip-ring assemblies and their current collectors shall be suitable for operation at pollution level II, III or IV of table 2 of **IEC 60071-2** (see also **3.3.5.2**).

Information : Table 2 of **HD 637** also gives the matters related.

The manufacturer's recommendations shall be followed regarding special measures to prevent a gradual reduction in the insulation values due to unfavourable ambient conditions (e.g. deposits of conductive dust, chemical attack).

13.8.6 Conductor system sectioning Where conductor wires or conductor bars are arranged so that they can be divided into isolated sections, suitable design measures shall be employed to prevent the energization of adjacent sections by the current collectors themselves.

13.8.7 Construction and installation of conductor wire, conductor bar systems and slip-ring assemblies Conductor wires, conductor bars and slip-ring assemblies used for HV power circuits shall be grouped separately from those used for LV circuits.

Conductor wires, conductor bars and slip-ring assemblies shall be capable of withstanding, without damage, the mechanical forces and thermal effects of short-circuit currents.

Removable covers for conductor wire and conductor bar systems laid underground or underfloor shall be so designed that they cannot be opened without the aid of a tool.

Where conductor bars are installed in a common metal enclosure, the individual sections of the enclosure shall be bonded together and earthed at several points depending upon their length. Metal covers of conductor bars laid underground or underfloor shall also be bonded together and earthed.

NOTE : For equipotential bonding or protective conductor connection to covers or cover plates of metal enclosures or underfloor ducts, the usual metal hinges are considered sufficient to ensure continuity.

Underground and underfloor conductor bar ducts shall have drainage facilities.

14 Wiring practices

14.1 Connections and routing

14.1.1 General requirements The means of introduction of a HV cable with its glands, bushings, etc., into an enclosure shall ensure that the degree of protection of the enclosure is not reduced (see **12.3**).

All connections shall be secured against accidental loosening. The means of connection shall be suitable for the cross-sectional area and nature of the conductor being terminated. In the case of aluminium or aluminium alloy conductors, particular consideration shall be given to the problems of intrinsic plasticity (flowing) and electrolytic corrosion. Screw and compression joints of conductors and connections to electrical equipment shall be designed to maintain the required contact pressure under load and short-circuit conditions. The recommendations of the cable supplier shall be followed regarding types of gland, box and methods of termination.

Identification tags shall be fixed on the cable at the cable terminations, and shall be legible, permanent, and appropriate for the physical environment.

14.1.2 Cable runs Cables shall be so installed or protected as to minimize the possibility of mechanical damage that may arise due to the use of the machine or by foreseeable misuse.

The bending radius of the cables and the conditions of laying shall be in accordance with the advice of the cable supplier.

Where it is necessary to disconnect and reconnect cables (e.g. for replacement of a motor), sufficient extra length shall be provided for this purpose.

Conductors and cables shall be adequately supported. In particular the terminations of cables shall be adequately supported to prevent mechanical stresses at the terminations of the conductors.

Cables shall be run from termination to termination without splices or joints. Where this is impracticable (e.g. on mobile machines, on machines having long flexible cables), splices or joints may be used.

High-voltage cables should be physically separated from low-voltage cables.

14.2 Identification of conductors Conductors shall be identifiable at each termination in accordance with the technical documentation (see clause **18**). Annex B, question 28 may be used for agreement between supplier and user regarding a preferred method of identification.

Where the protective conductor cannot be easily identified by its shape, position, or construction, it shall be clearly identified at accessible positions by the graphical symbol **IEC-60417-5019** or by the bicolour combination GREEN-and-YELLOW.

14.3 Flexible cables Flexible cables subject to movement shall be supported in such a way that there is no mechanical strain on the anchorage points nor any sharp flexing. Where this is achieved by the use of a loop, it shall have sufficient length to provide for a bending radius of the cable of at least 10 times the diameter of the cable.

The connecting ends of the cables shall be relieved from stress and thrust. Cable sheaths shall be secured against stripping and the cable ends protected against torsion.

The points of connection shall be arranged in such a manner that the cables cannot be kinked.

Flexible cables of machines shall be installed or protected so as to minimize the possibility of external damage due to factors that include the following cable uses or foreseeable misuse:

— being run over by the machine itself;

— being run over by vehicles or other machines;

— coming into contact with the machine structure during movements;

— running in and out on cable baskets, or on or off cable drums;

— acceleration forces and wind forces on festoon systems or suspended cables;

— excessive rubbing by cable collectors;

— exposure to excessive radiated heat.

The cable sheath shall be resistant to

— the normal wear which can be expected from movement, and

— the effects of atmospheric contaminants (e.g. oil, water, coolants, dust).

The cable handling system shall be so designed that lateral cable angles do not exceed 5°, avoiding torsion in the cable when

— being wound on and off cable drums, and

— approaching and leaving cable guidance devices.

Measures shall be taken to ensure that at least two turns of flexible cable remain on a drum.

The allowable cable bending radius shall be ensured, unless otherwise agreed with the cable manufacturer, as follows:

— cable drums and rollers shall be used which ensure that the operative winding diameter is at least 25 times the cable diameter. The minimum radius at the guide and deflector pulleys as well as towards the stationary cable termination point shall not be, in any direction, less than 15 times the cable diameter. The straight distance between two bends of an S-shaped deflection or a deflection to another level shall be at least 20 times the cable diameter. The minimum bending radius at the feeding points which are within the travel way shall be at least 15 times the cable diameter;

— for roller conveyors, the distance between the individual rollers shall be so set as to avoid excessive bending at a roller. This applies especially under conditions of high travel speeds, frequent reversed bending and usage at the maximum permissible tensile stress of the conductors.

These requirements also apply to similar devices, for example mobile cable supports, cable carriages.

14.4 Plug/socket combinations Plug/socket combinations which remain connected during normal service shall be

— of the retaining type requiring the use of a key or tool to prevent unintended disconnection, or

— of a type interlocked with a switch to prevent disconnection under load.

In cases where plug/socket combinations are required, for example to extend a flexible power supply cable, they shall be retained in a way requiring the use of a key or tool and it is recommended that, in addition, they be interlocked with a switch.

The plug/socket combination shall meet the requirements of **5.2.2 c**). Appropriate warning signs in accordance with **17.2** shall be affixed to the plug/socket combination. Appropriate instructions for safe use shall be provided in accordance with clause **18**.

14.5 Dismantling for shipment Where it is necessary that wiring be disconnected for shipment, termination points or plug/socket combinations shall be provided at the sectional points. Such termination points shall be suitably enclosed and plug/socket combinations shall be protected from the physical environment during transportation and storage.

14.6 Cable trays Cable trays shall be rigidly supported and positioned at a sufficient distance from moving parts and in such a manner as to minimize the possibility of damage or wear. In areas where human passage is required, the cable trays shall be mounted at least 2 m above the working surface.

15 Electric motors and associated equipment

15.1 General The requirements of clause **15** of **JIS B 9960-1** apply.

15.2 Motor connection boxes Motor-mounted devices, for example brakes, temperature sensors, plugging switches, tachometer generators, shall be terminated either

— in a connection box separate from the motor connection box, or

— in a compartment of the motor connection box separate from the high-voltage terminations.

16 Accessories

16.1 Accessories for earthing and short-circuiting live parts Accessories for earthing and short-circuiting all live parts to the earthing system (see **5.4**) which are appropriate for the HV equipment shall be provided in sufficient quantity to facilitate work being carried out in safety on the live parts of the HV equipment of the machine (see annex B). These accessories shall comply with the requirements of **IEC 61230**.

16.2 Voltage detectors Voltage detectors complying with **IEC 61243-1**, suitable for verifying that live parts on the machine are de-energized shall be provided. These voltage detectors shall include means of verifying that they are in working order (see annex B).

Information : **7.3.3** of **HD 637** also gives the relevant requirements.

16.3 Accessories for safe working Accessories for safe working in the vicinity of live HV equipment (e.g. mobile screens, insertable insulated partitions) shall be provided (see annex B).

Information : Relevant requirements are given in **7.3.5** of **HD 637**.

17 Marking, warning signs and reference designations

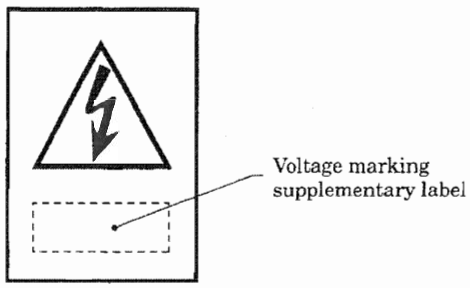
17.1 General The electrical equipment shall be marked with the supplier's name, trade mark, or other identifying symbol.

Warning signs, nameplates, markings and identification plates shall be of sufficient durability to withstand the physical environment involved.

Marking and reference designations shall be in accordance with clause **17** of **JIS B 9960-1**.

17.2 Warning signs (live mark) Enclosures that do not otherwise clearly show that they contain electrical devices shall be marked with a combined sign according to figure 10 of **JIS B 9706-1**. This shall show a black lightning flash on a yellow background within a black triangle, shaped in accordance with the graphical symbol **IEC-60417-5036**, the whole in accordance with symbol **B.3.6** of **JIS Z 9101** and shall be marked in the supplementary label with the relevant voltage.

The warning sign shall be plainly visible on the enclosure door or cover.



Graphical symbol **IEC 60417-5036**

18 Technical documentation The requirements of clause **18** of **JIS B 9960-1** apply. In addition the documentation, especially the operating manual, shall include the proper procedures for the use of the accessories specified in clause **16** of this Standard (**JIS B 9960-11**).

19 Testing and verification

19.1 General This part of **JIS B 9960** gives general requirements for the HV equipment of machines. The relevant tests for a particular machine type will be given in the dedicated product standard. Where there is no dedicated product standard for the machine, the appropriate tests may include one or more of the following but shall always include the earthing system tests (see **19.2**):

- verification that the HV equipment is in compliance with the technical documentation;
- earthing system tests (see **19.2**);
- insulation resistance tests (see **19.3**);
- voltage tests (see **19.4**);
- functional tests (see **19.5**);
- IP tests for HV equipment outside electrical operating areas (see **19.6**).

When these tests are performed, it is recommended that they follow the sequence listed above.

19.2 Earthing system tests Tests shall be carried out on

— the machine installation,

— the connections between the machine installation and the external installation (machine bonding conductors),

— any earthing system provided as part of the electrical installation of the machine,

to verify that the earthing system satisfies the requirements for protection against indirect contact according to **6.3**.

Information : **9.6** of **HD 637** gives the requirement relating to the testings.

19.3 Insulation resistance tests The insulation resistance, between the power circuit conductors and the protective bonding circuit, measured at a voltage equal to the rated voltage of the HV equipment or 5 kV, whichever is the lower value, shall be not less than 1 MΩ. The test may be made on individual sections of the complete HV installation. As an exception, for certain parts of HV equipment, incorporating for example busbars, conductor wire or conductor bar systems or slip-ring assemblies, a lower minimum value of insulation resistance is permitted in agreement with the manufacturer.

19.4 Voltage tests Details of the voltage tests shall be agreed between the supplier and user.

A guide for voltage tests after installation on site is given in annex DD of **IEC 60298**.

Information 1 The Ordinances of Ministry of Economy, Trade and Industry, "Ordinance Concerning Technical Requirements for Electrical Appliances and Materials" article 5 clause 2 and "Interpretation of Ordinance Concerning Technical Requirements for Electrical Appliances and Materials" article 17 give the conditions for dielectric strength test.

2 **IEC 60298** annex DD differs from **JEM 1425** annex DD in technical content.

19.5 Functional tests The functions of electrical equipment shall be tested, particularly those related to safety and safeguarding.

19.6 IP tests for HV equipment outside electrical operating areas IP tests are not necessary for type-tested HV equipment that provides a minimum degree of protection against direct contact of IPXXDH.

For other electrical equipment, the appropriate tests specified in **JIS C 0920** shall be carried out.

19.7 Retesting Where a portion of the machine and its associated electrical equipment is changed or modified, that portion shall be reverified and retested, as is appropriate (see **19.1**).

Related standards:

EN 50178 : 1997 *Electronic equipment for use in power stations*

HD 637 : 1999 *Power installations exceeding 1 kV a.c.*

JEM 1425 : 2000 *A.C. metal-enclosed switchgear and controlgear for rated voltages above 1 kV and up to and including 52 kV* (The Japan Electrical Manufacturers' Association)

JCS 168 : 1995 *Calculation of the current rating of power cables for rated voltages up to and including 33 kV—Part 1 : Formula and constant* (The Japanese Electric Wire & Cable Maker's Association)

Annex A (informative)
Examples of machines covered by this Standard

This annex A (informative) supplements the matters related to the text and does not constitute the provision of this Standard.

The following list shows examples of machines whose HV equipment should conform to this Standard.

— rolling machines;

— paper and board making machines;

— internal mixers (rubber and plastics);

— tunnelling machines;

— mining and quarrying machines;

— conveyors;

— cranes;

— ship loaders/unloaders;

— material (e.g. coal) stocking-out and reclaiming machines.

Annex B (informative)

Inquiry form for the HV equipment of machines

This annex B (informative) supplements the matters related to the text and does not constitute the provision of this Standard.

NOTE : There is a separate inquiry form for the LV equipment of machines in annex B of **JIS B 9960-1**.

It is recommended that the following information is provided by the intended user of the HV equipment. It facilitates an agreement between the user and supplier on basic conditions and additional user requirements to ensure proper design, application and utilization of the HV equipment of the machine (see **4.1** of the text).

Name of manufacturer/supplier _____

Name of end user _____

Tender/order No. _____ Date _____

Type of machine/serial number _____

1. Are there to be modifications as allowed for within this Standard ?

   YES _____ NO _____

Operating conditions—Special requirements (see **4.4** of the text)

2. Ambient temperature range _____
3. Humidity range _____
4. Altitude _____
5. Environmental (e.g. corrosive atmospheres, particulate matter, EMC) _____
6. Radiation _____
7. Vibration, shock _____
8. Special installation and operation requirements (e.g. flame retardant requirements for cables and conductors)

   _____

Power supply(ies) and related conditions (see **4.3** of the text)

9. Anticipated voltage fluctuations (if more than ± 10 %) _____
10. Anticipated frequency fluctuations (if more than in **4.3.2** of the text) _____

    Specification of short-term value _____

11. Indicate possible future changes in HV equipment that will require an increase in the electrical HV supply requirements

_____

12. Indicate for each source of electrical supply required:

    Nominal voltage (V) _____ a.c. _____ d.c. _____

    If a.c., number of phases _____ Frequency _____ Hz

    Prospective short-circuit current at the point of supply to the machine _____ kA r.m.s. (see also question 15)

    Fluctuations outside values given in **4.3.2** of the text _____

13. What size and type of cable will be used to connect the supply to the machine ?

    — cable cross-sectional area _____

    — conductor material _____

    — cable type _____

    Is monitoring of the protective conductor required ? YES _____ NO _____

14. Expected single earth-fault current of the HV supply system ?

    Value: _____ Duration: _____

    Type of earthing

    — isolated neutral

    — resonant earthing

    — low impedance neutral earthing

    — resonant earthing and temporary low impedance neutral earthing ?

    Expected double earth-fault current in systems with isolated neutral or resonant eathing ?

    Value: _____ Duration: _____

15. Does the user or the supplier provide the overcurrent and earth fault protection of the supply conductors ? (see **7.2.2** of the text).

_____

    Type and setting of

    — overcurrent protective devices _____

    — earth fault protective devices _____

16. Supply disconnecting and earthing devices

    Type of disconnecting device to be provided ? _____

    Are locking facilities to lock in the OFF position required for earthing switches ?

    YES _____ NO _____

17. Limit of power up to which three-phase a.c. motors may be started directly across the incoming supply lines ? _____ kW

18. Motors

With reference to **7.3** of **JIS B 9960-1** (overload protection of motors):

— May the number of motor overload detection devices be reduced ?

YES _____ NO _____

— Is protection under loss of phase condition required ?

YES _____ NO _____

— Is protection under stalled rotor condition required ?

YES _____ NO _____

Other considerations

19. Identification (see **17.1** of the text) _____

20. Inscriptions/special markings

— mark of certification YES _____ NO _____ If YES, which one ? _____

— on HV-equipment ? _____ In which language ? _____

21. Technical documentation (see **18.1** of **JIS B 9960-1**)

On what media ? _____ In which language ? _____

22. Size, location, and purpose of ducts, open cable trays, or cable supports to be provided by the user? (see **18.5** of **JIS B 9960-1**) (additional sheets to be provided where necessary)

_____

23. If 'two-hand control' is to be provided, state the type: _____

Where it is type III, state the time limit (0.5 s maximum) within which each pair of push-buttons is to be operated _____

24. Indicate if special limitations on the size or weight affect the transport of a particular machine or the controlgear assemblies to the installation site:

— maximum dimensions _____

— maximum weight _____

25. In the case of machines with frequent repetitive cycles of operation dependent on manual control, how frequently will cycles of operation be repeated ? _____ per hour

For what length of time is it expected that the machine will be operated at this rate without subsequent pause ? _____ min

26. In the case of specially built machines, is a certificate of operating tests with the loaded machine to be supplied ? YES _____ NO _____

In the case of other machines, is a certificate of operating type tests on a loaded prototype machine to be supplied ? YES _____ NO _____

27. For cable-less control systems, specify the time delay before automatic machine shutdown is initiated in the absence of a valid signal ? (see **9.2.7.3** of **JIS B 9960-1**) _____ s

28. Do you need a specific method of conductor identification to be used for the conductors referred to in **14.2** ?

    YES _____ NO _____ Type _____

29. Type and quantity of accessories for:

    — earthing and short-circuiting (see **16.1** of the text) Type _____ No. _____

    — voltage detectors (see **16.2** of the text) Type _____ No. _____

    — safe working (see **16.3** of the text) Type _____ No. _____

Annex C (informative)

Method of calculation for the cross-sectional area of bare protective conductors in supply systems with direct earthing or low impedance earthing of the neutral

This annex C (informative) supplements the matters related to the text and does not constitute the provision of this Standard.

Because the probability of receiving a burn from touching the protective conductor during the time when a short-time earth fault occurs is very low, the cross-sectional area is dimensioned for a temperature of 200 °C. The formula below can be used to calculate the required cross-sectional area of bare conductors that will carry the earth-fault current for a period of up to 5 s without exceeding a conductor temperature of 200 °C, assuming adiabatic behaviour:

$$S = (I_E/k)\, t^{1/2}$$

where

S	is the required cross-sectional area	mm^2
I_E	is the effective earth-fault current (r.m.s. value)	A
t	is the time of fault current flow	s
k	is the factor for bare conductors with an allowable maximum temperature of 200 °C, based on an initial temperature of 40 °C	$A(sec)^{1/2}mm^{1/2}$
	153 for copper,	
	99 for aluminium,	
	56 for galvanized steel.	

Annex D (informative)

Relationship between cable rated voltages and highest voltage for HV equipment

This annex D (informative) supplements the matters related to the text and does not constitute the provision of this Standard.

The voltage designation of a cable is given in terms of U_0/U (U_m). Annex D table 1 shows the relationship between these factors.
where

U_0 is the rated power frequency voltage between conductor and earth or metallic screen for which a cable is designed;

U is the rated power frequency voltage between conductors for which the cable is designed (also used as the "nominal system voltage");

U_m is the maximum value of the "highest system voltage" for which the HV equipment may be used (see **IEC 60038**).

Annex D Table 1

Unit: kV

Rated voltages of cables and the related fittings		Highest voltage for HV equipment
U_0	U	U_m
1.8	3	3.6
3.6	6	7.2
6	10	12
8.7	15	17.5
12	20	24
18	30	36

Annex E (informative)

Rationalization of the use of terms relating to earthing and protective bonding

This annex E (informative) supplements the matters related to the text and does not constitute the provision of this Standard.

Annex E table 1 shows uses of terms relating to earthing and protective bonding in this Standard (**JIS B 9960-11**) and **HD 637**.

Annex E Table 1

JIS B 9960-11	HD 637
Earth electrode Not defined No specific requirements Used in **3.9**	**Earth electrode** Defined in **2.7.3** as follows: a conductor which is in conductive contact with the earth, or a conductor, which is embedded in concrete, which is in contact with the earth via a large surface (for example a foundation earth electrode) (**IEV 604-04-05**, **826-04-02**)
Earthing system Defined in **3.9** as follows: locally limited system of conductively connected earth electrodes or metal parts of equal effectiveness (for example tower footings, armourings, metal cable sheaths), of earthing conductors and of bonding conductors No specific requirements Used in **3.25**, **5.2.1**, **5.2.3.2**, **6.3.2**, **8.1**, **8.2.2**, **8.2.3**, **16.1**, **19.1**, **19.2**	**Earthing system** Defined in **2.7.6** as follows: a locally limited system of conductively connected earth electrodes or metal parts of equal effectiveness (for example tower footings, armourings, metal cable sheaths), of earthing conductors and of bonding conductors (**IEV 604-04-01**)
Earthing conductor Not defined No specific requirements Used in **3.9**, **3.25**	**Earthing conductor** Defined in **2.7.4** as follows: a conductor which connects a part of the installation that has to be earthed to an earth electrode or which connects earth electrodes and is laid outside of the soil or is buried in the soil and insulated from it (**IEV 826-04-07**) NOTE: Where the connection between part of the installation and the earth electrode is made via a disconnecting link, surge arrester counter, surge arrester control gap etc., then only that part of the connection permanently attached to the earth electrode is an earthing conductor.

Annex E Table 1 (continued)

JIS B 9960-11	HD 637
Machine bonding conductor Defined in **3.25** as follows: conductor connecting the machine equipotential bonding to the earthing system (**IEV 826-04-07**) (This is an earthing conductor as used in **HD 637**). No specific requirements Used in **8.2.1**, **8.2.3**, **8.2.6**, **8.2.7**, **19.2**	**Machine bonding conductor** Not used
Protective conductor Defined in **3.35** as follows: conductor required by some measures for protection against electric shock for electrically connecting any of the following parts: (**IEV 826-04-05**, modified) — exposed-conductive-parts; — extraneous-conductive-parts; — main earthing terminal Requirements in **8.2.2**, **13.7.1** Used in **3.16**, **3.34**, **8.2.1**, **8.2.3**, **8.2.6**, **13.8.3**, **13.8.7**, **14.2**, annex C	**Protective conductor** Not defined Used only for connections between LV equipment and HV earthing systems
Equipotential bonding Defined in **3.15** as follows: provision of electric connections between conductive parts, intended to achieve equipotentiality (**IEV 195-01-10**) Requirements in clause **8** Used in **3.16**, **3.25**, **8.1**, **8.2.1**, **13.8.7**	**Equipotential bonding** Defined in **2.7.14.1** as follows: the conductive connection between conductive parts, to reduce the potential differences between these parts
Equipotential bonding conductor Defined in **3.16** as follows: protective conductor provided for protective-equipotential-bonding (**IEV 195-02-10**) No specific requirements Used in **8.2.1**, **8.2.6**	**Bonding conductor** Defined in **2.7.5** as follows: a conductor providing equipotential bonding

Annex E Table 1 (concluded)

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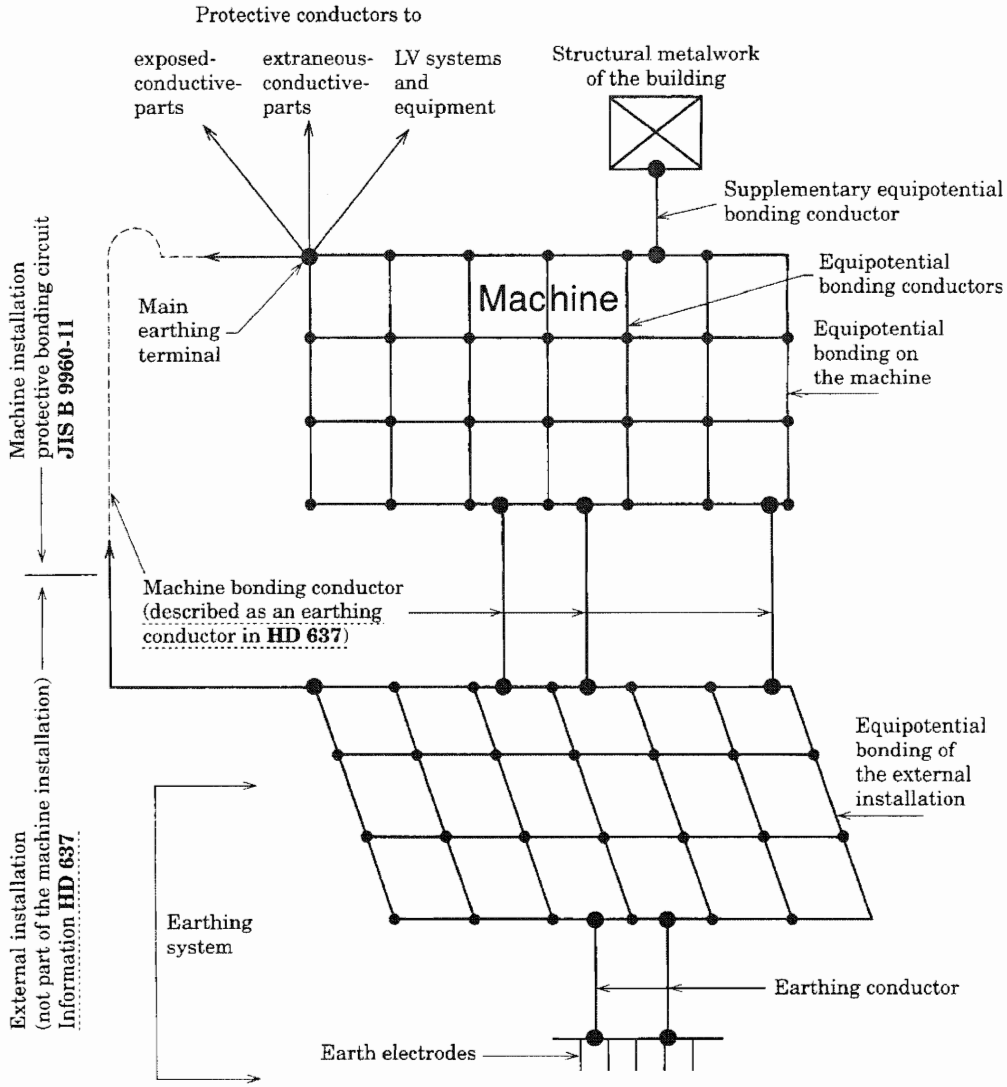
Supplementary equipotential bonding conductor No defined Requirements in **8.2.7** Used in **8.2.7**	**Supplementary equipotential bonding conductor** Not used
Protective bonding circuit Defined in **3.34** as follows: the whole of the protective conductors and conductive parts used for protection against electric shock in the event of an insulation failure No specific requirements Used in **6.3.1**, **6.3.3**, **8.2.1**, **8.2.3**, **8.2.4**, **8.2.5**, **8.2.6**, **8.2.7**, **13.8.2**, **19.3**	**Protective bonding circuit** Not used



Annex E Figure 1 Explanation of the terms relating to earthing and protective bonding